Landscape Dynamics and Terrestrial Vegetation

Protocol: Vegetation Complexes Integrated Protocol

Parks Where Protocol Will Be Implemented: ALAG, ANIA, KATM, KEFJ, LACL

Vital Signs Addressed: Vegetation Composition and Structure, Land Cover/Land Use, Sensitive Vegetation Communities

Justification/Issues Being Addressed: Vegetation is integral to ecosystem function, energy transfer, and element cycling, and has the potential to both affect and respond to environmental drivers (Bennett et al. 2004). Enabling legislation for SWAN parks includes provisions for the preservation of arctic tundra, boreal forest, and coastal rainforest, among other vegetation types. Global and regional drivers expected to affect these ecosystems include increasing climatic variability, changing atmospheric chemistry and pollutant loads, and increasing variability in pathogens and pests in the forested sites.

Human-induced changes in biological diversity and modification of ecosystem processes, including primary productivity and element cycling, are two of the most pronounced ecological trends of the last century (Vitousek et al. 1997). Human activities, including motorized and nonmotorized access, resource development, subsistence activities, and activities associated with private in-holdings and/or adjacent lands, have the potential to cause rapid and long-lasting changes to ecosystems of SWAN (Bennett et al. 2004). Model simulations and empirical data indicate that a combination of land use change and climatic variation could have profound impacts on subarctic vegetation (e.g., Rupp et al. 2000, Jorgenson et al. 2001), both through vegetation loss and changes in species composition.

Changes in species composition and structure, particularly age- and size-class structure, may have important intrinsic effects at the ecosystem level (Nichols et al. 1998), and may affect habitat connectivity (Lindborg and Eriksson 2004) and landscape-scale patterns of species richness or endemism (e.g., Sabo et al. 2005). High-latitude plant communities are expected to be particularly sensitive to increased climatic variation (e.g., Spicer and Chapman 1990, Epstein et al. 2004) and physical disturbance (e.g., Auerbach et al. 1997). As such, they may serve as early indicators of environmental change on the landscape (Bennett et al. 2004). Vegetation Composition and Structure focuses on changes in vegetation in response to environmental drivers, whereas Land Cover/Land Use focuses on responses associated with human activity, e.g., vegetation loss. Sensitive Vegetation Communities highlights changes in ecosystems that are strongly controlled by physical factors (e.g., hydrology, thermal regime) or that may be at the edge of their environmental tolerance (Spicer and Chapman 1990, Lesica and McCune 2004, Epstein et al. 2004).

Specific Monitoring Questions and Objectives to be Addressed by the Protocol:

<u>Vegetation Composition and Structure</u>

Questions:

- Are the distribution and abundance of major land cover classes (incorporating vegetation composition and structure) changing through time in the SWAN landscape?
- Are species composition, vegetation structure (physiognomy), and woody species regeneration changing through time in focal ecosystems in SWAN parks?

Objectives:

- Map long-term, landscape-scale changes in the distribution and extent of major land cover classes in SWAN using satellite imagery and/or aerial photographs.
- Quantify long-term changes in the extent of land cover classes in SWAN.
- Quantify long-term changes in the distribution of land cover classes in SWAN.

- Estimate long-term changes in species richness, cover, and diversity in focal ecosystems in KATM, KEFJ, and LACL.
- Where applicable, estimate long-term changes in the density of seedlings, saplings, and mature trees and/or shrubs at these sites.

Land Cover/Land Use

Questions:

- Is vegetation loss occurring in SWAN parks?
- Are patterns of land use changing in and adjacent to SWAN parks?

Objectives:

- Map long-term, landscape-scale changes in vegetation to identify areas where vegetation loss is occurring due to human activities in and adjacent to SWAN.
- Document changes in land-use patterns in and adjacent to SWAN parks.

Sensitive Vegetation Communities

Question:

- Is species composition changing through time in focal ecosystems in SWAN parks?

Objectives:

- Estimate long-term changes in species richness, cover and diversity in focal ecosystems in KATM, KEFJ, and LACL.
- Where applicable, estimate long-term changes in the density of seedlings, saplings, and mature trees and/or shrubs at these sites.

Basic Approach:

Vegetation Composition and Structure

We will monitor vegetation composition and structure both at the landscape scale, using aerial photographs and/or remotely sensed data (e.g., Sturm et al. 2001, Zhou et al. 2001, Stow et al. 2004), and at the ecosystem scale, using targeted, ground-based sampling. Monitoring will employ the following tools:

(i) Landscape scale: Multispectral satellite imagery

Satellite imagery and aerial photos will be acquired at 10-year intervals for retrospective and future analyses of landscape-scale vegetation change (ANIA, KATM, KEFJ, LACL). Landsat MSS, TM, and ETM+ imagery are available for southwest Alaska between 1972-1977 (262 ft [80 m]) and 1990-2004 (98 ft [30 m]), and satellite coverage is expected to resume in the state by 2009. We will explore the use of widely applied change detection algorithms (e.g., univariate image differencing, change vector analysis) to identify areas of change in paired sets of images. These techniques involve the subtraction of one set of georectified spectral data from another and avoid the issue of consistency inherent in post-classification comparisons (Coppin et al. 2004). Field validation and high-resolution imagery (e.g., IKONOS) and aerial photos will be critical to interpretation of summer scenes, as will ongoing land cover classifications supported by the NPS-USGS Interagency Vegetation Mapping/Multi-Resolution Land Characteristics Program. Rectified satellite image data and derivative products will be archived in the SWAN databases or served through the USGS in the Alaska Geographic Data Clearinghouse. Interpretations will be stored as geographic information system (.shp) or flat file data, as appropriate.

(ii) Ecosystem scale: Ground-based sampling

Ground-based sampling required for the detection of more subtle, ecosystem-level change will be initiated at two to three index sites in each of three parks (KEFJ, KATM, LACL). These sites will target the dominant ecosystems in the parks, including open spruce woodland and low shrub tundra (3 and 15% of land cover in KATM and LACL, respectively), and spruce-hemlock forest (8% of cover in KEFJ). Where possible, index sites will be collocated with instrumented weather stations and/or hydrological monitoring stations. Species cover and frequency will be measured at index sites every year for 5 yr to develop estimates of interannual variability (cf. Lesica and Steele 1996), and at 3-yr intervals thereafter using a rotating panel design. A series of parallel transects with a random start will be used to locate sampling points at each site, following a modification of the design used by the Bonanza Creek Long Term Ecological Research site (http://www.lter.uaf.edu/bcef/exp_design.cfm) and the Heartland Network (DeBacker et al. 2004).

In addition to the intensively sampled index sites, an extensive array of sites will be selected using a spatially balanced probabilistic sampling framework (e.g., GRTS design), weighted by site accessibility and landscape attributes (e.g., elevation, aspect classes). Extensive sites will be visited in the order that they are assigned and will be sampled if they meet criteria for the target environments. The extensive sites will be visited less frequently (e.g., every 7-10 yr), but will expand the area of inference from index sites. Extensive sites may or may not be instrumented, and the number of sites per park will depend on sample heterogeneity and available funding. To expand our sampling frame in the short-term, we will develop a Memorandum of Understanding with the USFS for the acquisition of Forest Inventory and Analysis (FIA) data.

Land Cover/Land Use

Methods used to detect change in Land Cover/Land Use will be the same as those used for Vegetation Composition and Structure ((i) Multispectral satellite imagery), but will focus on vegetation loss due to human activities rather than more subtle, environmentally induced vegetation change.

Sensitive Vegetation Communities

The monitoring approach for Sensitive Vegetation Communities will be similar to that for Vegetation Composition and Structure ((ii) Ground-based sampling). In sensitive communities characterized by tree or shrub cover (e.g., white spruce/tundra ecotones; ericaceous wetlands), permanent subplots consisting of nested 10.7, 43, and 108 ft^2 (1, 4, and 10 m^2) plots will be established at fixed intervals along transects for determination of cover in herbaceous, shrub, and tree layers, respectively. In herbaceous communities (e.g., alpine tundra/nunataks), nested 2.8 and 10.7 ft^2 (0.25 and 1 m^2) plots will be used to estimate species cover and frequency. The sample size required for an estimate of a single population mean (90% confidence interval) will be calculated from randomly placed quadrats in the field (cf. Elzinga et al. 1998). Plots will be sampled every 3-5 yr for the first 10 yr to determine short-term species-level variation (cf. Lesica and Steele 1996), and every 7-10 yr thereafter.

Principal Investigators and NPS Leads:

Vegetation Composition and Structure

(i) Multispectral satellite imagery
- Warren Cohen, USFS-PNW, Corvallis, OR (PI)
- Robert Kennedy, USFS-PNW, Corvallis, OR (Co-PI)
- Amy Miller, NPS-SWAN (NPS Lead)
- Page Spencer, NPS-ARO

(ii) Ground-based sampling
- Amy Miller, NPS-SWAN (NPS Lead)

Land Cover/Land Use Change

Multispectral satellite imagery
- Warren Cohen, USFS-PNW, Corvallis, OR (PI)
- Robert Kennedy, USFS-PNW, Corvallis, OR (Co-PI)
- Amy Miller, NPS-SWAN (NPS Lead)
- Page Spencer, NPS-ARO

Sensitive Vegetation Communities

Ground-based sampling
- Amy Miller, NPS-SWAN (NPS Lead)
- Page Spencer, NPS-ARO

Development Schedule, Budget, and Expected Interim Products:

Vegetation Composition and Structure

(i) Multispectral satellite imagery

2006 Develop draft protocol for change detection ($85,000).

2007 Protocol review and testing ($76,000).

2008 Implementation ($30,000).

(ii) Ground-based sampling

2007 Develop draft protocol for ground-based monitoring ($15,000).

2008 Protocol review and testing ($53,000).

2009 Implementation ($10,000-$45,000).

Land Cover/Land Use

Same as for (i) Multispectral satellite imagery, above. Costs are included in those for Vegetation Composition and Structure.

2006 Develop draft protocol for change detection.

2007 Protocol review and testing.

2008 Implementation.

Sensitive Vegetation Communities

Same as for (ii) Ground-based sampling, above. Costs for protocol development and testing are included in those for Vegetation Composition and Structure. Costs for implementation will vary with number and location of sites visited.

2007 Develop draft protocol for ground-based monitoring.

2008 Protocol review and testing.

2009 Implementation ($35,000-$60,000).

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